REMARKS

Claims 1, 3-9, 11-15, and 18-20 are pending in this application. Claims 1, 3-6, 8-9, 11, and 13 have been amended. Claims 2 and 10 have been canceled. No new matter has been added. Applicants note that the claims have been amended in consideration of JP2002-58279, which was cited during prosecution of applicants' counterpart Japanese patent application, to more clearly distinguish the claims. An Information Disclosure Statement including an English translation of this document is being filed concurrently herewith.

Claims 1-4 and 6-14 stand rejected under 35 USC 102(b) over McClelland (U.S. 6,586,904). Claims 5, 15, and 18-20 stand rejected under 35 USC 103(a) over McClelland in view of Kushida (US 6,545,443). Applicants traverse these rejections for the following reasons.

Claim 1 is directed to a method of compensating for differences between an applied DC link voltage and a predetermined DC link voltage in an electrical machine. The electrical machine comprises a rotor, at least one phase winding, and a controller. The controller comprises a memory storing <u>a voltage compensation map comprising a plurality of correction factors</u>. The method includes measuring the applied DC link voltage, obtaining a correction factor by addressing the voltage compensation map using the applied DC link voltage, and <u>applying the obtained correction factor to the angular position of energization of the phase winding</u>.

Accordingly, for example, a change in voltage supplied to the electrical machine can be compensated for to avoid adverse effects on the performance of the electrical machine. More particularly, a controller for a switched reluctance motor can comprises a speed control map, which stores a turn-on angle and a turn-off angle for each of a plurality of different speeds. In response to a signal indicative of motor speed, the controller selects from the map the corresponding turn-on and turn-off angles and uses the selected angles to control the excitation of the winding. However, the angles stored in the speed control map are optimized

for a particular mains voltage, e.g. 230 V if the motor is intended to be used in Europe or 120 V if it is intended to be used in the U.S. Unfortunately, the mains voltage is not always constant and instead can vary with time. For example, in Europe, the variance in the mains voltage can be ±10%. Changes in voltage may adversely affect the performance of the motor. For example, a drop in voltage would mean that less current is driven into the winding over an electrical cycle and thus the output power of the motor would drop.

In order to compensate for changes in the voltage, and thus achieve a more constant output power, the controller stores a voltage compensation map (see Fig. 9). The voltage compensation map stores a correction value for each of a plurality of voltages. In response to a signal indicative of the voltage of the power supply, the controller can select the corresponding correction value from the voltage compensation map and apply the correction to both the turn-on and turn-off angles (the angular position of energization of the phase winding).

Thus, a controller of an electrical machine implementing the method of claim 1 can monitor the speed of the motor and the voltage of the power supply, select from the speed control map turn-on and turn-off angles corresponding to the speed of the motor, and select from the voltage compensation map a correction value corresponding to the voltage of the power supply. The controller then applies the correction value to the turn-on and turn-off angles selected from the speed control map and uses the corrected turn-on and turn-off angles to excite the winding.

McClelland describes a controller for a switched reluctance motor. McClelland's controller stores a map of turn-on and turn-off angles for use in exciting a winding of the motor. The map stores turn-on and turn-off angles for each of a plurality of speeds and a plurality of torques. In response to signals indicative of motor speed and motor torque, the controller selects the corresponding turn-on and turn-off angles and uses the selected angles to excite the winding.

McClelland recognizes that the voltage of the mains supply is not constant. However, McClelland compensates for changes in voltage in a very different way from that of the claimed invention. In McClelland, the controller calculates the ratio of V_c/V_a, where V_c is the expected voltage and V_a is the actual voltage. The controller then multiplies the motor speed and the motor torque by this ratio to obtain a compensated speed value and a compensated torque value. <u>The compensated speed and torque values are then used to select the turn-on and turn-off angles from the control map</u>. Finally, the controller excites the winding using the selected angles. See, e.g., McClelland, col. 5, lines 47-54 and col. 6, lines 3-9.

The claimed invention's technique for voltage compensation differs from McClelland's technique. The controller of the claimed invention corrects the turn-on and turn-off angles (the angular position of energization of the phase winding) directly in response to changes in voltage using correction factors from a stored voltage compensation map. In contrast, <u>McClelland corrects the speed and torque values, which are then used to ***select*** potentially different turn-on and turn-off angles</u>. This difference between the claimed invention and McClelland has the following substantive implications, which also counsel against any finding of obviousness of the claimed invention.

The voltage compensation method employed by McClelland assumes that a link exists between speed and voltage. In particular, McClelland assumes that any change in voltage can be treated as if the motor speed has changed. So if the voltage is higher than expected, the controller of McClelland treats this as if the motor is running faster than expected. Conversely, if the voltage is lower than expected, the controller treats this as if the motor is running slower than expected. In contrast, the voltage compensation method employed by the claimed invention makes no such link. An obvious consequence of this is that the controller of the claimed invention uses the same correction value irrespective of speed of the motor, which is not the case with the controller of McClelland. A not so obvious consequence,

however, is that the controller of the claimed invention enables better control of the motor in response to changes in voltage, as explained below.

McClelland assumes that there is a linear relationship between changes in voltage and changes in speed. In particular, a change in the supply voltage of ΔV is equivalent to a change in motor speed of $\Delta V/V_a$. Putting it another way, the same output power might be achieved if, in response to a change in voltage of ΔV, the speed of the motor is assumed to have changed by $\Delta V/V_a$. However, this is a gross oversimplification, and the behavior of the motor is not so simple, as illustrated below with reference to an example. The claimed invention, on the other hand, stores a correction value for each of a plurality of voltages. The correction value is then applied directly to the turn-on and turn-off angles. As a result, the behavior of the motor may be better controlled at each individual voltage level. As a result, constant output power may be achieved irrespective of changes in voltage.

With the controller of McClelland, the resolution of the voltage compensation is dictated by the speed/torque control map. For example, assume that the map stores a turn-on angle and a turn-off angle every 1000 rpm, and the controller rounds down the compensated speed value to the nearest 1000 rpm. Now assume that the motor is running at 80,000 rpm and that the voltage is 120 V (which is the expected voltage). A short time later, the voltage increases to 121.4 V, and thus the compensated speed value is 80,000 x 121.4/120 = 80,933. The controller rounds down the compensated value to 80,000 and thus the turn-on and turn-off angles are unchanged. Only when the voltage increases to 121.5 V, which would result in a compensated speed value of 81,000 rpm, are different turn-on and turn-off angles selected. Therefore, in McClelland the voltage resolution (which in this example is 1.5 V) is dictated by the resolution of the speed/torque control map (which in this example is 1000 rpm). In contrast, the controller of the claimed invention stores a voltage compensation map that is independent of the speed control map. This then allows for finer voltage resolution. Again, assume that the speed control map stores a turn-on angle and a turn-off angle every 1000 rpm,

and the controller rounds down the speed value to the nearest 1000 rpm. As before, the motor is running at 80,000 rpm and the voltage is 120 V (which is the expected voltage). A short time later, the voltage increases to 121.4 V. The voltage compensation map has a resolution of 0.2 V and so the controller selects and applies a correction value to the turn-on and turn-off angles. Consequently, unlike the controller of McClelland, the controller of the claimed invention uses different turn-on and turn-off angles in response to the change in voltage.

In the above example, the controller of McClelland has a voltage resolution of 1.5 V, while the controller of the claimed invention has a voltage resolution of 0.2 V. Arguably, the speed/torque control map of McClelland could store turn-on and turn-off angles every 150 rpm, rather than every 1000 rpm, such that the voltage resolution approaches 0.2 V. However, this would then dramatically increase the size of the speed/torque control map, which stores both a turn-on angle and a turn-off angle for every speed and torque. In contrast, the voltage compensation map stores only a correction value, which is smaller (in terms of memory capacity) than an angle, let alone two angles (e.g., a correction value of 0.1 requires less memory to store than a turn-on angle of -10° and a turn-off angle of 140°). As such, the controller of the claimed invention provides not only better control of the motor but achieves better control in a way that makes efficient use of memory.

To further illustrate this distinction, let us assume that the motor of the claimed invention and the motor of McClelland operate over the same speed range, e.g. between 80,000 and 100,000 rpm. The controller of the claimed invention comprises a speed control map that stores turn-on and turn-off angles every 1,000 rpm. Similarly, the controller of McClelland comprises a speed control map that stores turn-on and turn-off angles every 1,000 rpm. Both speed maps store angles that are optimized for 120 V. Now let us assume that the mains voltage can be one of 118.5 V, 120 V or 121.5 V. The controller of the claimed invention comprises a voltage compensation map that stores two correction values, corresponding to 118.5 V and 121.5 V. In contrast, the controller of McClelland stores

additional entries in the speed control map corresponding to speeds of 79,000 rpm (which represents an actual speed of 80,000 compensated at 118.5 V) and 101,000 rpm (which represents an actual speed of 100,000 compensated for 121.5 V), each entry comprising two angles. So the controller of the claimed invention stores two correction values, while the controller of McClelland stores four angles (i.e. two turn-on angles and two turn-off angles). Accordingly, even if the two controllers have the same voltage resolution, the controller of the claimed invention achieves voltage compensation using much less memory.

Finally, while we described above the controller of the claimed invention as comprising a speed control map, the controller might instead store a single turn-on and turn-off angle for driving the motor at a single speed. The controller would nevertheless continue to store the voltage compensation map, which could be used to correct the turn-on and turn-off angles to compensate for changes in the supply voltage. In contrast, the controller of McClelland is not capable of driving the motor at a single speed, i.e. storing a single turn-on and turn-off angle, because, since the controller of McClelland corrects speed and torque values, the controller must store a turn-on angle and a turn-off angle for a plurality of speeds and torques. This is yet another example of how the technique of the claimed invention differs from the technique of McClelland.

Therefore, McClelland does not disclose or suggest the invention defined by claim 1. The other cited art does not remedy the above-noted deficiencies of McClelland. Accordingly, claim 1 is allowable. The other claims are allowable for similar reasons. Applicants request that the Examiner withdraw the outstanding rejections and issue a Notice of Allowance.

In the event that the transmittal letter is separated from this document and the Patent and Trademark Office determines that an extension and/or other relief is required, applicants petition for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing Docket No. **424662013400**.

Respectfully submitted,

Dated: September 8, 2009

By: Christopher W. Ferguson
Registration No. 59,809

Morrison & Foerster LLP
1650 Tysons Boulevard, Suite 400
Mclean, Virginia 22102
Telephone: (703) 760-7389
Facsimile: (703) 760-7777